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Predicting subsurface uranium transport: Mechanistic modeling constrained by experimental data

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Depleted uranium (DU) munitions and their widespread use throughout conflict zones around the world pose a persistent health threat to the inhabitants of those areas long after the conclusion of active combat. However, little emphasis has been put on developing a comprehensive, quantitative tool for use in remediation and hazard avoidance planning in a wide range of environments. In this context, we report experimental data on U interaction with soils and sediments. Here, we strive to improve existing risk assessment modeling paradigms by incorporating a variety of experimental data into a mechanistic U transport model for subsurface environments.
20 different soils and sediments from a variety of environments were chosen to represent a range of geochemical parameters that are relevant to U transport. The parameters included pH, organic matter content, $CaCO_3$, Fe content and speciation, and clay content. pH ranged from 3 to 10, organic matter content from 6 to 120 g kg-1, $CaCO_3$ from 0 to 700 g kg-1, amorphous Fe content from 0.3 to 6 g kg-1 and clay content from 4 to 580 g kg-1. Sorption experiments were then performed, and linear isotherms were constructed. Sorption experiment results show that among separate sets of sediments and soils, there is an inverse correlation between both soil pH and CaCO¬3 concentration relative to U sorptive affinity. The geological materials with the highest and lowest sorptive affinities for U differed in $CaCO_3$ and organic matter concentrations, as well as clay content and pH.
In a further step, we are testing if transport behavior in saturated porous media can be predicted based on adsorption isotherms and generic geochemical parameters, and comparing these modeling predictions with the results from column experiments. The comparison of these two data sets will examine if U transport can be effectively predicted from reactive transport modeling that incorporates the generic geochemical parameters. This work will serve to show whether a more mechanistic approach offers an improvement over statistical regression-based risk assessment models.